3.G.11 b. (cont'd) considered to be a separate space. Any such control room containing the main switchboard should, as far as practicable, be located so that the generator(s) are in sight and direct access to the generator(s) is facilitated. Each switchboard must be located in as dry a location as possible. Dripshields are required by 46 CFR 111.30-5(b). An equivalent installation is a switchboard that extends to the overhead and which cannot be subjected to leaks or falling objects. Piping above or adjacent to switchboards should be avoided. Piping which must be located in the vicinity of a switchboard must be provided with suitable spray shields and have only welded joints.

12. Circuit Protection Devices.

a. Purpose. Overcurrent devices, the two most common types being fuse and circuit breakers, offer protection against currents in excess of the rated current of equipment or the current-carrying capacity (ampacity) of a conductor. The purpose of properly coordinated overcurrent protection is to recognize, locate, and isolate faulted portions of the power system in order to minimize the damage to equipment and conductors, danger to personnel, and interruption of electrical power which may result from an overload, short circuit, or ground fault.

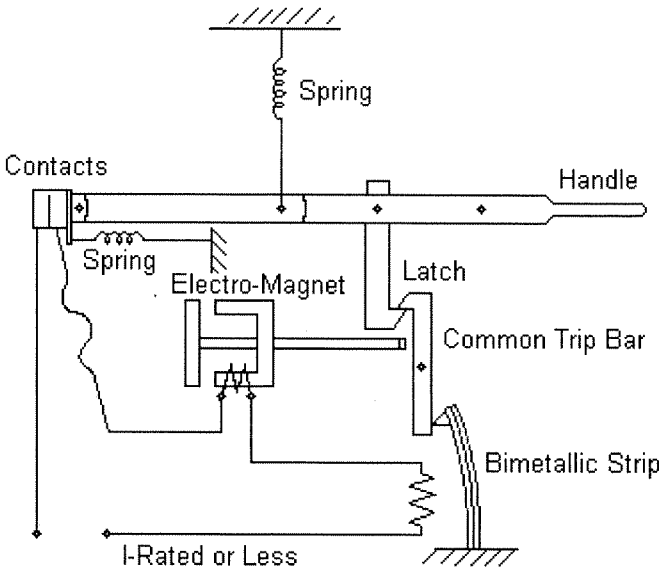
b. Circuit Breakers (46 CFR 111.54). Circuit breakers are devices which permit manual opening and closing of a circuit and which open the circuit automatically for a predetermined fault condition (usually overcurrent, but sometimes reverse power flow, under-voltage, or under-frequency) without damage to themselves when applied within their ratings. In effect, they are high current interrupting capacity switches with automatic trip elements. The circuit breakers most commonly found in marine applications respond to overcurrent, tripping when the current magnitude exceeds a specific value for a specific length of time. Low voltage (600 volts AC and below) circuit breakers are usually constructed with an integral overcurrent trip element within the circuit breaker housing.

In medium voltage systems, instrument transformers and protective relays separate from the circuit breakers are often used. Current transformers and voltage transformers are connected to the power system and allow the protective relays to "see" the conditions in the system without exposing them to the high system current and voltage levels. Protective relays interpret the information provided by the instrument transformers to discriminate between tolerable and fault/intolerable conditions. Upon detection of an intolerable condition, the protective relay initiates a tripping impulse to the circuit breaker, which isolates the faulted part of the power system.

When a circuit breaker opens an energized circuit, an arc is drawn between the opening contacts. This arc must be extinguished in order to interrupt the circuit. Circuit breakers are commonly classified according to the medium in which the contacts open. The common designations are air circuit breaker (which includes molded case circuit breakers), vacuum breakers, and SF6 (sulfur hexafluoride) breakers. Air circuit breakers are the most common type found in low voltage, relatively low current circuits for which the air around us serves as a suitable dielectric, preventing continued arcing between

3.G.12 b. (cont'd) the contacts after they have parted. Most air circuit breakers employ a bank of metal fins around the contacts to quickly extinguish arcs. As the arc passes between the fins it is split, cooled, and extinguished.

A molded-case circuit breaker is a type of air circuit breaker that is assembled as an integral unit in an insulated housing. Most molded-case breakers are provided with both a thermal trip for sustained overloads and a magnetic trip for instantaneous tripping on high fault currents. The operating mechanism that opens and closes the contacts includes a powerful spring that is charged when the breaker is closed. The trip actuator may have a number of inputs, but it must have a common mechanical output that releases the operating mechanism and uses the spring energy to open the contacts. Traditional circuit breakers have, for each pole a bimetallic thermal trip element and an electromagnetic (instantaneous) trip unit that initiate the mechanical motion of the trip bar which, in turn, releases the operating mechanism to open the contacts. Note that actuation of the common trip bar opens all the poles of the breaker simultaneously. This is illustrated in the figure below.



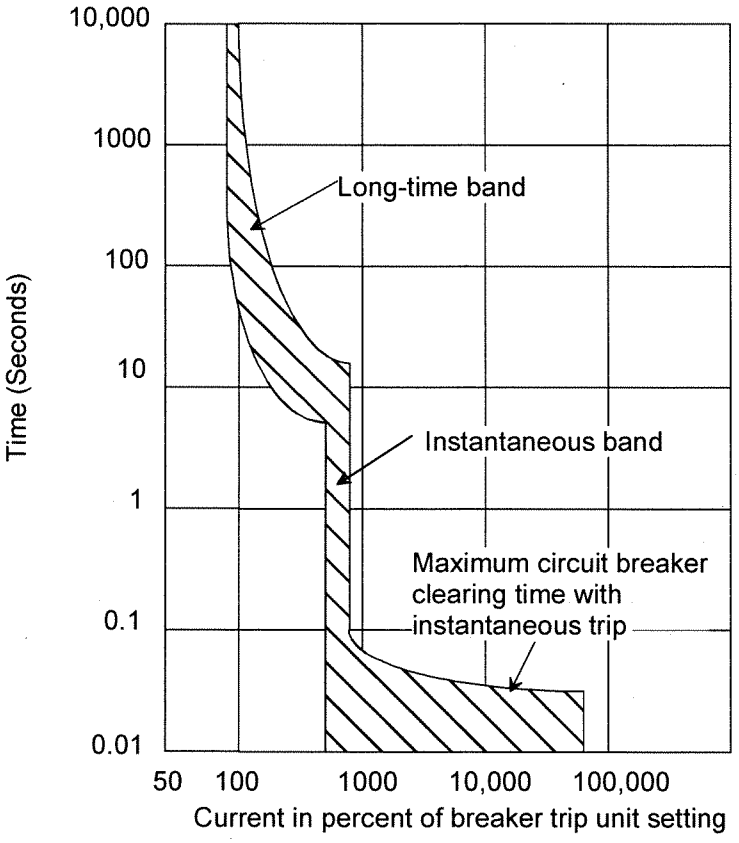

Electronic trip systems have been developed which replace the moving thermal-magnetic devices with solid-state electronic sensors and a single trip solenoid. By reducing the number of mechanical moving parts used to release the operating mechanism, electronic trip units can be made inherently more vibration and shock (impact) resistant. In addition, the electronic trip unit can be more closely adjusted and is less sensitive to ambient temperature because no motion of the trip actuator occurs until the trip signal is sent to the solenoid by the electronic circuit. With these advantages and the option for additional protection features, electronic trip units may soon replace thermal-magnetic elements for overcurrent protection.

The interrupting rating of a circuit breaker is the highest RMS (Root Mean Squared) current at rated voltage that the breaker is intended to interrupt in normal service. In practical circuits containing both resistance and reactance, most short-circuit currents will be

3.G.12 b. (cont'd) asymmetrical during the first few cycles after the short occurs. This asymmetry, due to a DC current component, will decay during the first few cycles until the current becomes symmetrical. The asymmetrical current, although it lasts only a short time, can greatly exceed the corresponding symmetrical fault current and the circuit breaker must be able to withstand the asymmetrical value. Under the ANSI standards presently applicable to low voltage fuses and circuit breakers, interrupting ratings are expressed in terms of the symmetrical RMS current to facilitate equipment comparison and selection. Circuit breakers meeting UL 489, although having only a symmetrical rating, are tested under conditions that evaluate their ability to withstand the "worst-case" asymmetrical current. It is not necessary to evaluate the device for asymmetrical current. Medium voltage circuit breakers have a first-cycle asymmetrical rating.

The continuous current rating of a circuit breaker is the continuous current the breaker will carry, without tripping, in the ambient temperature for which it is calibrated. Higher current will initiate tripping, though the current level must be sustained for some minimum length of time in order to actually trip the breaker. Circuit breakers trip on overcurrent according to a time-current response curve established by the manufacturer. A typical circuit breaker time-current characteristic curve is shown in the figure below.

Time-Current Response Curve



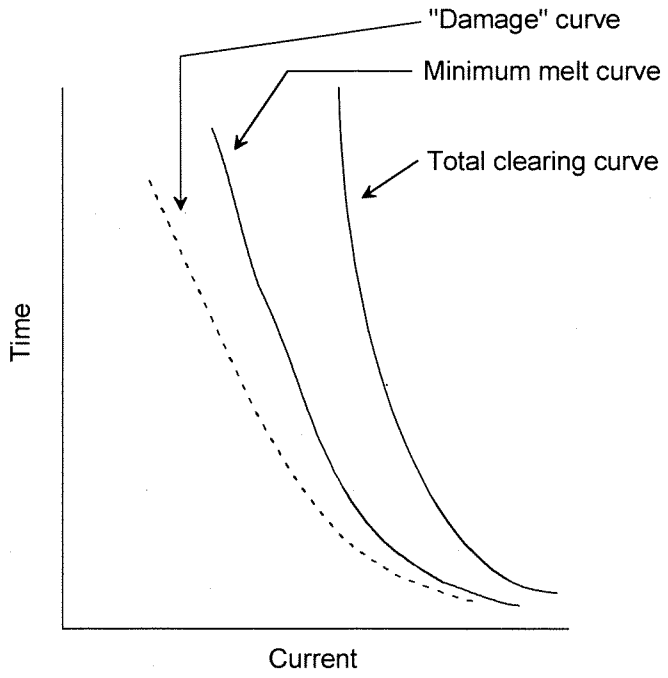

Circuit breakers that respond to overcurrent may have an inverse-time trip, an instantaneous trip, or both.

3.G.12 b. (cont'd) The term "instantaneous" here means only that no intentional time delay has been introduced, although some finite minimum time is required for any circuit breaker to interrupt a circuit. The curves indicate the length of time a particular current level must be sustained in order to trip a particular breaker. These and similar time-current curves for fuses are used in the process of coordinating the various overcurrent devices in the power system.

c. Fuses (46 CFR 111.53). Fuses are overcurrent protective devices containing a circuit-opening fusible element that is heated and severed by the passage of overcurrent. Fuses are among the few components required by the Electrical Engineering Regulations to be listed by an independent laboratory recognized by the Coast Guard (see 46 CFR 111.53-1(a)(3)). Fuses listed or labeled by a "nationally recognized testing laboratory" which has received recognition by OSHA are acceptable. Only "one-time" fuses may be used; renewable link cartridge-type fuses and Edison-base fuses (the screw-in type formerly used in residential fuse boxes) may not be used.

The interrupting rating (or capacity) refers to the highest RMS alternating current (or direct current depending upon the application), which the fuse is designed to interrupt without charring or cracking of the fuse tube or external arcing. The continuous current rating, or ampere rating, is the current level which the fuse will carry continuously without deterioration or excessive temperature rise. While fuses are often regarded as instantaneous circuit interrupting devices, they follow an extremely inverse time-circuit characteristic curve as shown below.

Fuse Characteristic Curve




The total clearing time curve shows the maximum time, including arcing time and manufacturing tolerances, for the fusible element to open the circuit. The minimum melt curve represents the minimum time